# PLANT ITEM MATERIAL SELECTION DATA SHEET

ISSUED BY
RPP-WTP PDC

R10672004

## PWD-VSL-00015 & PWD-VSL-00016 (PTF)
## Acidic/Alkaline Effluent Vessel

- Design Temperature (°F)(max/min): 237/0
- Design Pressure (psig) (max/min): 15/-10
- Location: incell
- PJM Discharge Velocity (fps): 40
- Drive Cycle: 17 % (at 40 fps)

## Offspring items

**PWD-VSL-00015–**
PWD-VSL-00101 – PWD-VSL-00105
PWD-PJM-00001 – PWD-PJM-00008
PWD-RFD-00101 – PWD-RFD-00105

**PWD-VSL-00016–**
PWD-VSL-00111 – PWD-VSL-00115
PWD-PJM-00011 – PWD-PJM-00018,
PWD-RFD-00111 – PWD-RFD-00115

**Contents of this document are Dangerous Waste Permit affecting**

**Operating conditions are as stated on attached Process Corrosion Data Sheets**

## Options Considered:

- Normal operating conditions.

## Materials Considered:

| Material (UNS No.) | Relative Cost | Acceptable Material | Unacceptable Material |
|---|---|---|---|
| Carbon Steel | 0.23 | | X |
| 304L (S30403) | 1.00 | | X |
| 316L (S31603) | 1.18 | X | |
| 6% Mo (N08367/N08926) | 7.64 | X | |
| Alloy 22 (N06022) | 11.4 | X | |
| Ti-2 (R50400) | 10.1 | | X |

**Recommended Material: 316 (max 0.030% C; dual certified)**

**Recommended Corrosion Allowance: 0.040 inch (includes 0.024 inch corrosion allowance and 0.016 inch general erosion allowance; localized protection will be provided as necessary as discussed in section j)**

## Process & Operations Limitations:

- Develop rinsing/flushing procedure for acid operation or ensure a sufficient alkaline heel exists during acid addition.

STEVEN WAKEMAN VAIL
STATE OF WASHINGTON
39250
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES: 12/07/07

4/18/06

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This bound document contains a total of 8 sheets.

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## Corrosion Considerations:

These vessels receive acidic/alkaline cleaning effluent and solutions from equipment in the CNP, CXP and UFP systems, as well as non-routine transfers from other PWD system vessels.

**a General Corrosion**
The normal operating temperature is 80 to 100 °F. Periodically, steam can heat incoming streams to 212 °F (with a design temperature of 237 °F). The high temperature is anticipated to be localized and of short duration.

In Hamner's data (1981), 304 (and 304L) lists a corrosion rate in NaOH of less than 20 mpy (500 μm/y) at 77 °F and over 20 mpy at 122 °F. He shows 316 (and 316L) has a rate of less than 2 mpy up to 122 °F and 50 % NaOH. Dillon (2000) and Sedriks (1996) both state that the 300 series alloys are acceptable in up to 50 % NaOH at temperatures up to about 122 °F or slightly above. Davis (1994) states the corrosion rate for 304L in pure NaOH will be less than about 0.1 mpy up to about 212 °F though Sedriks (1996) states the data beyond about 122 °F are low because of the presence of oxidizing agents – similar to nitrates and nitrites. Danielson & Pitman (2000), based on short term studies, suggest a corrosion rate of about 0.5 mpy for 316L in simulated waste at boiling, >212 °F. Divine's work (1986) with simulated-radwaste evaporators showed that 304L was slightly more resistant to corrosion (<0.2 mpy) than was 316L (<0.6 mpy). Zapp (1998) notes that the Savannah River evaporator vessels, operating at about 300 °F, are made of 304L and have suffered no failures in about 30 years; 304L heat transfer surfaces have failed however after about 10 years.

The amount of fluoride is expected to be small although ultrafilter washing with nitric acid might result in a high acidic fluoride concentration. Wilding and Paige (1976) have shown that in 5 % nitric acid with 1000 ppm fluoride at 290 °F, the corrosion rate of 304L can be as high as 5 mpy. If it is assumed that the corrosion rate is roughly proportional to the fluoride concentration, even at high temperatures, normal conditions will result in low rates – the unknown is the acid wash conditions. If acid is added from another source, the vessel should either be flushed prior to addition of acid or retain a sufficient alkaline heel.

If the solutions vary between strongly oxidizing (permanganate), alkaline, and acidic, then the conditions are similar to those in nuclear reactor systems during decontamination and enhanced corrosion should be expected.

*Conclusion*:
304L or 316L will be sufficiently resistant to the waste solution at the expected temperatures with a probable general corrosion rate of less than 1 mpy. Based on the Savannah River experience with Hanford-like waste at higher temperatures, 304L is expected to be satisfactory in hot waste. Rinsing procedure should remove as much waste as possible followed by a water rinse prior to acid cleaning to prevent acid cleaning in the presence of excessive fluoride.

**b Pitting Corrosion**
Chloride is known to cause pitting in acid and neutral solutions with 316L more resistant than 304L. Dillon (2000) is of the opinion that in alkaline solutions, pH>12, chlorides are likely to promote pitting only in tight crevices even with 304L. Dillon and Koch (1995) are of the opinion that fluoride will have little effect. Jenkins (2000) has stated that localized corrosion can occur under the deposits on tubes, probably due to the chlorides. Further, Revie (2000) and Uhlig (1948) note that nitrates inhibit chloride pitting. Wilding and Paige (1976) note that nitric acid inhibits chloride attack though their data are at higher temperatures and concentrations.

The vessels are shown to have substantial concentrations of chlorides and fluorides under normal operation. No indication of how much can be present from ultrafilter washing. At the stated levels of halides and under alkaline conditions, 304L is expected to be satisfactory even at 237 °F. If the pH drops below 12, the halides must be removed. Pulse jet mixers provide sufficient agitation to prevent deposits.

*Conclusion*:
Under normal conditions with agitation, 304L may be acceptable. However, because of non-routine low pH conditions, the more pitting resistant 316L is recommended for conservatism.

**c End Grain Corrosion**
End grain corrosion only occurs in metal with exposed end grains and in highly oxidizing acid conditions.

*Conclusion*:
Not applicable to this system.

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**d Stress Corrosion Cracking**
The exact amount of chloride required to cause stress corrosion cracking is unknown. In part this is because the amount varies with temperature, metal sensitization, and the environment but also because chloride tends to concentrate under heat transfer conditions, by evaporation, and electrochemically during a corrosion process. Hence, even as little as 10 ppm can lead to cracking under some conditions. Generally, as seen in Sedriks (1996) and Davis (1987), stress corrosion cracking does not usually occur below about 140 °F. The "L" grades of both 304 and 316 are also more resistant to cracking than the higher carbon versions. Further, the presence of nitrate is expected to inhibit cracking. If the concentrations are as stated, stress corrosion cracking will be minimized. Because of the high chloride concentrations, the likelihood of residual halides is high. Therefore a minimum of 316L is recommended

*Conclusion:*
With the normal operating environment, 316L stainless steel is expected to be acceptable.

**e Crevice Corrosion**
The pitting discussion covers this area.

*Conclusion*:
See Pitting

**f Corrosion at Welds**
Corrosion at welds is not considered a problem in the proposed environment.

*Conclusion*:
Weld corrosion is not considered a problem for this system.

**g Microbiologically Induced Corrosion (MIC)**
The proposed operating temperatures are slightly high for microbial growth but, additionally, the location of the system in the process suggests little chance of the introduction of microbes. Further, the alternation between acidic and alkaline conditions is not conducive to their growth.

*Conclusion*:
MIC is not expected to be a problem.

**h Fatigue/Corrosion Fatigue**
At the operating pH, corrosion fatigue is not expected to be a problem in a proper designed vessel.

*Conclusions*
Not considered to be a problem.

**i Vapor Phase Corrosion**
The vapor phase portion of the vessel will be spattered with solution. The presence of wash rings within the vessels will allow this area to be rinsed.

*Conclusion*:
Not considered to be a problem.

**j Erosion**
Based on past experiments by Smith & Elmore (1992), the solids are soft and erosion is not expected to be a concern for the vessel wall. Based on 24590-WTP-RPT-M-04-0008, a general erosion allowance of 0.016 inch is adequate for components with maximum solids content up to 27.3 wt%. Additional 316L stainless steel should be provided as localized protection for the applicable portions of the bottom head to accommodate PJM discharge velocities of up to 12 m/s with solids concentrations of 2.0 wt% for a usage of 65 % (PWD-VSL-00015) or 54 % (PWD-VSL-00016) operation as documented in 24590-WTP-M0E-50-00003. PWD-VSL-00015 requires at least 0.093-inch additional protection and PWD-VSL-00016 requires at least 0.077 inch additional protection. The 2.0 wt% is considered to be conservative and is based on the WTP Prime Contract maximum. During normal operation, the solids content of the PWD-VSL-00015/16 vessels is expected to be well below the anticipated maximum.

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The wear of the PJM nozzles can occur from flow for both the discharge and reflood cycles of operation. At least 0.065 inch, for PWD-VSL-00015, and 0.054 inch, for PWD-VSL-00016, of additional 316L stainless steel should be provided on the inner surface of the PJM nozzle to accommodate wear due to PJM discharge and suction velocities with solids concentrations of 2.0 wt% for 65 % (PWD-VSL-00015) or 54 % (PWD-VSL-00016) operation as documented in 24590-WTP-M0E-50-00003.

*Conclusion:*
The recommended corrosion allowance provides sufficient protection for erosion of the vessel wall. Additional localized protection for the bottom head will accommodate PJM discharge velocities and for the PJM nozzles will accommodate PJM discharge and reflood velocities.

**k Galling of Moving Surfaces**
Not applicable.

*Conclusion:*
Not applicable.

**l Fretting/Wear**
Fretting/wear is not anticipated due to the lack of moving parts.

*Conclusion:*
Not a concern.

**m Galvanic Corrosion**
In the proposed environment and with the lack of dissimilar alloys, there are no potential differences. Therefore, no galvanic corrosion is expected.

*Conclusion:*
Not a concern.

**n Cavitation**
None expected.

*Conclusion:*
Not believed to be of concern.

**o Creep**
The temperatures are too low to be a concern.

*Conclusion:*
Not applicable.

**p Inadvertent Nitric Acid Addition**
Higher chloride contents and higher temperatures usually require higher alloy materials. Nitrate ions inhibit the pitting and crevice corrosion of stainless alloys. Furthermore, nitric acid passivates these alloys; therefore, lower pH values brought about by increases in the nitric acid content of process fluid will not cause higher corrosion rates for these alloys. The upset condition that was most likely to occur is lowering of the pH of the vessel content by inadvertent addition of 2 M nitric acid. Lowering of pH may make a chloride-containing solution more likely to cause pitting of stainless alloys. Increasing the nitric acid content of the process fluid adds more of the pitting-inhibiting nitrate ion to the process fluid. In addition, adding the nitric acid solution to the stream will dilute the chloride content of the process fluid.

*Conclusion:*
The recommended materials will be able to withstand a plausible inadvertent addition of 2 M nitric acid for a limited period.

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## References:

1. 24590-WTP-M0E-50-00003, *Wear Allowance for WTP Waste Slurry Systems*
2. 24590-WTP-RPT-M-04-0008, Rev. 2, *Evaluation Of Stainless Steel Wear Rates In WTP Waste Streams At Low Velocities*
3. 24590-WTP-RPT-PR-04-0001, Rev. B, *WTP Process Corrosion Data*
4. Danielson, MJ & SG Pitman, 2000, *Corrosion Tests of 316L and Hastelloy C-22 in Simulated Tank Waste Solutions*, PNWD-3015 (BNFL-RPT-019, Rev 0), Pacific Northwest Laboratory, Richland WA.
5. Davis, JR (Ed), 1987, *Corrosion, Vol 13*, In "Metals Handbook", ASM International, Metals Park, OH 44073
6. Davis, JR (Ed), 1994, *Stainless Steels*, In ASM Metals Handbook, ASM International, Metals Park, OH 44073
7. Dillon, CP (Nickel Development Institute), Personal Communication to J R Divine (ChemMet, Ltd., PC), 3 Feb 2000.
8. Divine, JR, 1986, Letter to A.J. Diliberto, *Reports of Experimentation*, Battelle, Pacific Northwest Laboratories, Richland, WA 99352
9. Hamner, NE, 1981, *Corrosion Data Survey*, Metals Section, 5th Ed, NACE International, Houston, TX
10. Jenkins, CF. SRTC, teleconference with JR Divine, RPP-WTP, 16 February, 2000.
11. Koch, GH, 1995, *Localized Corrosion in Halides Other Than Chlorides*, MTI Pub No. 41, Materials Technology Institute of the Chemical Process Industries, Inc, St Louis, MO 63141
12. Revie, WW, 2000. *Uhlig's Corrosion Handbook*, 2nd Edition, Wiley-Interscience, New York, NY 10158
13. Sedriks, AJ, 1996, *Corrosion of Stainless Steels*, John Wiley & Sons, Inc., New York, NY 10158
14. Smith, H. D. and M. R. Elmore, 1992, *Corrosion Studies of Carbon Steel under Impinging Jets of Simulated Slurries of Neutralized Current Acid Waste (NCAW) and Neutralized Cladding Removal Waste (NCRW)*, PNL-7816, Pacific Northwest Laboratory, Richland, Washington.
15. Uhlig, HH, 1948, *Corrosion Handbook*, John Wiley & Sons, New York, NY 10158
16. Wilding, MW & BE Paige, 1976, *Survey on Corrosion of Metals and Alloys in Solutions Containing Nitric Acid*, ICP-1107, Idaho National Engineering Laboratory, Idaho Falls, ID.
17. Zapp, PE, 1998, *Preliminary Assessment of Evaporator Materials of Construction*, BNF—003-98-0029, Rev 0, Westinghouse Savannah River Co., Inc for BNFL Inc.

## Bibliography:

1. Agarwal, DC, *Nickel and Nickel Alloys*, In: Revie, WW, 2000. *Uhlig's Corrosion Handbook*, 2nd Edition, Wiley-Interscience, New York, NY 10158
2. Blackburn, LD to PG Johnson, Internal Memo, Westinghouse Hanford Co, *Evaluation of 240-AR Chloride Limit*, August 15, 1991.
3. Jones, RH (Ed.), 1992, *Stress-Corrosion Cracking*, ASM International, Metals Park, OH 44073
4. Phull, BS, WL Mathay, & RW Ross, 2000, *Corrosion Resistance of Duplex and 4-6% Mo-Containing Stainless Steels in FGD Scrubber Absorber Slurry Environments*, Presented at Corrosion 2000, Orlando, FL, March 26-31, 2000, NACE International, Houston TX 77218.
5. Van Delinder, LS (Ed), 1984, *Corrosion Basics*, NACE International, Houston, TX 77084

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24590-WTP-RPT-PR-04-0001, Rev. B
WTP Process Corrosion Data

## PROCESS CORROSION DATA SHEET

**Component(s) (Name/ID #)** Acidic/alkaline effluent vessels (PWD-VSL-00015,16)

**Facility** PTF

**In Black Cell?** Yes

| Chemicals | Unit[1] | Contract Maximum | | Non-Routine | | Notes |
|---|---|---|---|---|---|---|
| | | Leach | No leach | Leach | No Leach | |
| **Aluminum** | g/l | 2.02E+01 | 1.15E+01 | | | |
| **Chloride** | g/l | 4.28E+00 | 4.74E+00 | | | |
| **Fluoride** | g/l | 4.75E+00 | 5.32E+00 | | | |
| **Iron** | g/l | 7.14E+00 | 5.41E+00 | | | |
| **Nitrate** | g/l | 1.23E+02 | 1.23E+02 | | | |
| **Nitrite** | g/l | 2.20E+01 | 2.45E+01 | | | |
| **Phosphate** | g/l | 1.82E+01 | 1.78E+01 | | | |
| **Sulfate** | g/l | 8.54E+00 | 9.50E+00 | | | |
| **Mercury** | g/l | 7.79E-02 | 7.84E-02 | | | |
| **Carbonate** | g/l | 5.66E+01 | 5.46E+01 | | | |
| **Undissolved solids** | wt% | 1.3% | 1.4% | | | |
| **Other (NaMnO4, Pb,...)** | g/l | | | | | |
| **Other** | g/l | | | | | |
| **pH** | N/A | | | | | Note 3 |
| **Temperature** | °F | | | | | Note 2 |
| | | | | | | Note 4 |
| | | | | | | |
| | | | | | | |

**List of Organic Species:**

**References**

System Description: 24590-PTF-3YD-PWD-00001, Rev 1
Mass Balance Document 24590-WTP-M4C-V11T-00005, Rev A
Normal Input Stream #: PWD01, UFP27, UFP28, UFP32
Off Normal Input Stream # (e.g., overflow from other vessels): See section 4.9.9, Non-routine Operations
P&ID: 24590-PTF-M6-PWD-P0003, Rev 0
PFD: 24590-PTF-M5-V17T-P0022001 Rev. 0
Technical Reports:

**Notes:**

1. Concentrations less than 1x $10^{-4}$ g/l do not need to be reported; list values to two significant digits max.
2. T normal operation 80 °F to 100 °F (24590-PTF-MVC-PWD-00031, Rev 0)
3. pH 14 but could receive 2M nitric acid (pH -0.3) from UF cleaning, on non-routine basis.
4. 19M NaOH can be added to these vessels.

**Assumptions:**

**24590-WTP-RPT-PR-04-0001, Rev. B**
**WTP Process Corrosion Data**

### 4.9.9 Acidic/Alkaline Effluent Vessel (PWD-VSL-00015)

**Routine Operations**

The vessel is sized to accommodate one wash/cleaning cycle from ultrafiltration with allowances for the other small streams that are received along with enough space to neutralize material.

During normal operations, vessel PWD-VSL-00015 receives acidic/alkaline effluent from the following sources:

- Alkaline cleaning effluent via breakpot PWD-BRKPT-00015 from ultrafiltration feed vessels (UFP-VSL-00002A/B)
- Caustic rinse from cesium ion exchange columns (CXP-IXC-00001, CXP-IXC-00002, CXP-IXC-00003, and CXP-IXC-00004)
- Process condensate from cesium nitric acid recovery (CNP-HX-00002, 3, and 4)
- Nitric acid, demineralized water, and sodium hydroxide drains from reagent bulge UFP-BULGE-00001

**Non-Routine Operations that Could Affect Corrosion/Erosion**

During non-routine operations, vessel PWD-VSL-00015 receives acidic/alkaline effluent from the following sources:

- Caustic rinse from cesium ion exchange via caustic rinse collection tank (CXP-VSL-00004)
- Acidic cleaning effluent via breakpot PWD-BRKPT-00015 from ultrafiltration feed vessels (UFP-VSL-00002A/B)
- Caustic rinses from solids washing/leaching (UFP-VSL-00062A/B/C)
- During abnormal operations, vessel PWD-VSL-00015 receives effluent from the following source:
- Overflow from PWD-VSL-00016
- An air in-bleed is provided to dilute hydrogen generated in vessel PWD-VSL-00015. The level and temperature in vessel PWD-VSL-00015, as well as the temperature in the acidic/alkaline effluent breakpot, are monitored in the main control room. Pulse jet mixers are used to provide a uniform mixture during neutralization within vessel PWD-VSL-00015. An RFD supplies a representative sample of the vessel contents, which will be analyzed for pH in the laboratory. Excess acidic effluent is neutralized with 19 M sodium hydroxide supplied from a reagent header. Wash rings are used for vessel and breakpot washing. A vessel-emptying ejector is used for non-routine transfers to the plant wash vessel (PWD-VSL-00044).
- An RFD supplies a representative sample of the contents of vessel PWD-VSL-00015 for analysis. If the pH is confirmed to be 12 or above, RFDs transfer the high- active effluent from vessel PWD-VSL-00015 to the waste feed evaporator feed vessels (FEP-VSL-00017A or B) for recycle.
- Vessel PWD-VSL-00015 vents to the vessel vent caustic scrubber (PVP-SCB-00002) via the vessel vent header, overflows to the acidic/alkaline effluent vessel (PWD-VSL-00016), and ultimately overflows to vessel PWD-VSL-00033. Breakpot PWD-BRKPT-00015 vents to scrubber PVP-SCB-00002 via the vessel vent header and overflows to vessel PWD-VSL-00015.

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**WTP Process Corrosion Data**

## 4.9.10 Acidic/Alkaline Effluent Vessel (PWD-VSL-00016)

**Routine Operations**

The vessel is sized to accommodate one wash/cleaning cycle from ultrafiltration with allowances for the other small streams that are received along with enough space to neutralize material.

During normal operations, vessel PWD-VSL-00016 receives acidic/alkaline effluent from the following sources:

- Alkaline Acidic cleaning effluent via breakpot PWD-BRKPT-00016 from ultrafiltration feed vessels (UFP-VSL-00002A/B)
- Caustic leach solutions (UFP-VSL-00062A/B/C)
- Ultrafiltration solides wash (UFP-VSL-00062A/B/C)
- Nitric acid, demineralized water, and sodium hydroxide drains from reagent bulge UFP-BULGE-00002

**Non-Routine Operations that Could Affect Corrosion/Erosion**

- During non-routine operations, vessel PWD-VSL-00016 receives acidic/alkaline effluent from the following sources:
  - Caustic rinse from cesium ion exchange via caustic rinse collection tank (CXP-VSL-00004)
  - Caustic rinse from cesium ion exchange columns (CXP-IX-00001/2/3/4).
  - Process condensate from cesium nitric acid recovery (CNP-HX-00002, 3 and 4).
  - Alkline cleaning effluent via breakpot PWD-BRKPT-00016 from Ultrafiltration Feed Vessels (UFP-VSL-00002A/B).
  - Plant wash from PWD-VSL-00044.
  - Overflow from PWD-VSL-00015